Cornell Red Cloud: Campus-based Hybrid Cloud

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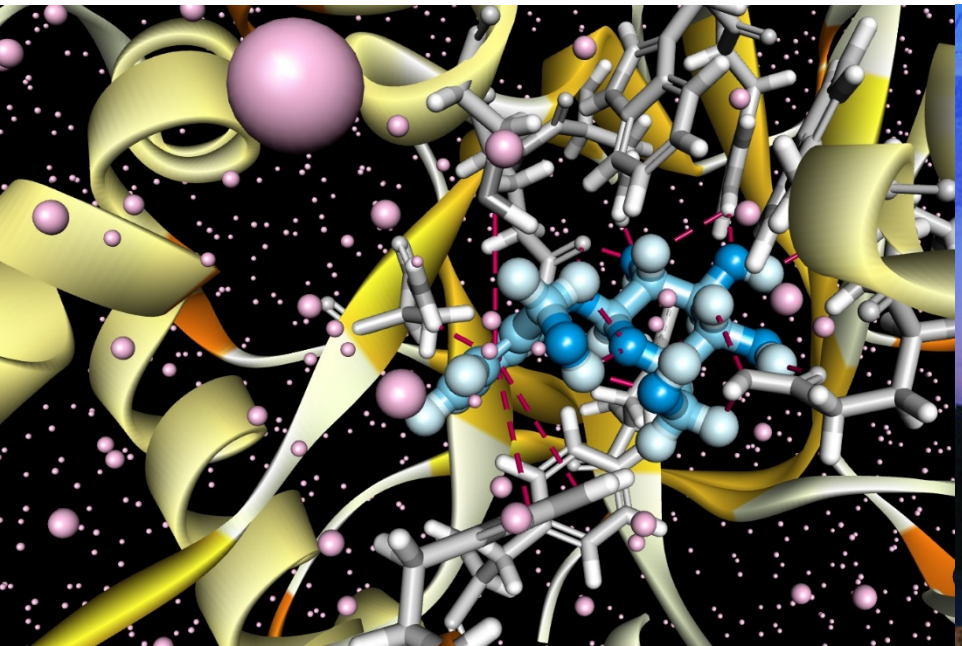
Cornell Center for Advanced Computing (CAC)

Profile

CAC mission, impact on research

- Research computing and consulting services
  - Mission: accelerate discovery and broaden impact
- Wide range of services
  - HPC cluster maintenance and storage to data management, programming, and visualization
- Impact on research
  - Supporting Cornell faculty with over $100 million in research funding from NSF, NIH, USDA, DOE, NASA …
  - Management roles in national cyberinfrastructure program
  - NSF Computer, Information Science & Engineering Advisory Committee



Red Cloud & Aristotle Cloud Federation

Overview

Red Cloud overview

- Launched 2011
- Motivation: for workloads not suitable for HPC batch queues
- Features
  - AWS-compatible API
    - Compute: EC2
    - Storage: object storage (S3); block storage (EBS)
    - Networking: elastic IP/security groups
    - Accounts and access management: IAM
  - 10 Gigabit Network Interconnect
  - No CPU/RAM over-subscription
  - Subscription model
    - Limits accidental research budget overruns

red cloud

Red Cloud infrastructure

- Cloud stack: Eucalyptus
- 2 locations
  - Cornell's main Ithaca campus
  - Weill Cornell Medicine NYC
- Compute: 472 CPU cores
  - Users can choose from instance types up to 28 cores/192GB RAM
- Storage
  - Storage in Ithaca cloud is hosted in a Ceph cluster with ~1 PB capacity
  - Storage in NYC cloud is hosted in a Dell SAN
- Networking
  - 10 Gbit Ethernet interconnect between cloud components
  - Each cloud has a 10 Gbit uplink to Cornell campus network

On-demand scalable infrastructure, deployed in minutes

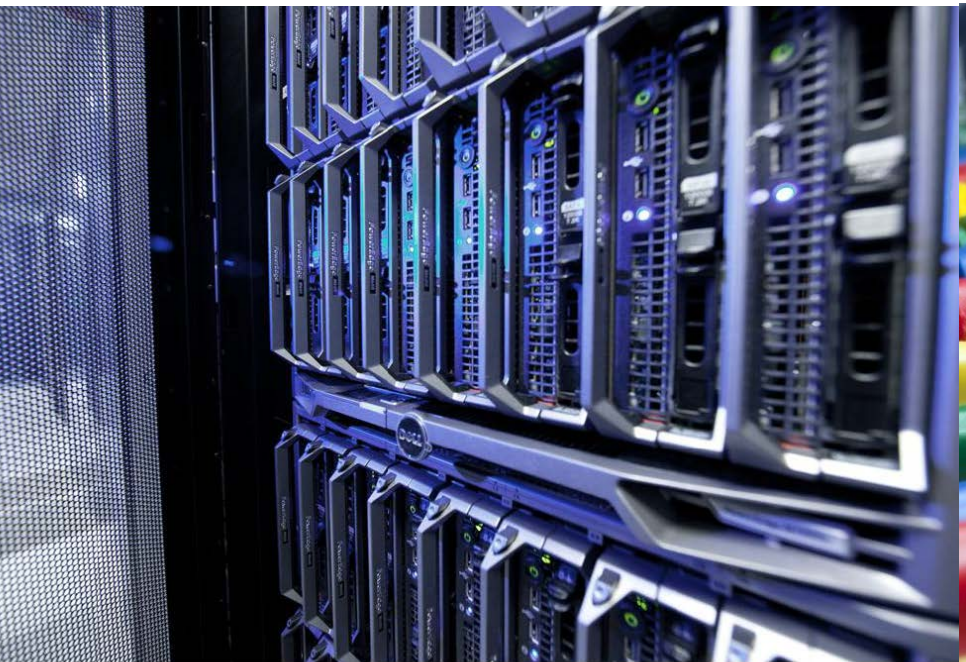
- Red Cloud gives users a fully customizable computing resource
  - Many instance sizes to choose from
  - Get root access to instances
  - Allocate block storage in increments of GB
  - Define network access policies via security groups
  - Managing cloud resources via web console, command line client, API
- Application examples
  - Develop/test code and burst production workload to AWS if necessary
  - Web portals
  - Interactive workloads
  - Software as a service: MATLAB MDCS Cluster
  - Virtualize center's internal infrastructure: web portals, file servers, Nagios monitor, etc.

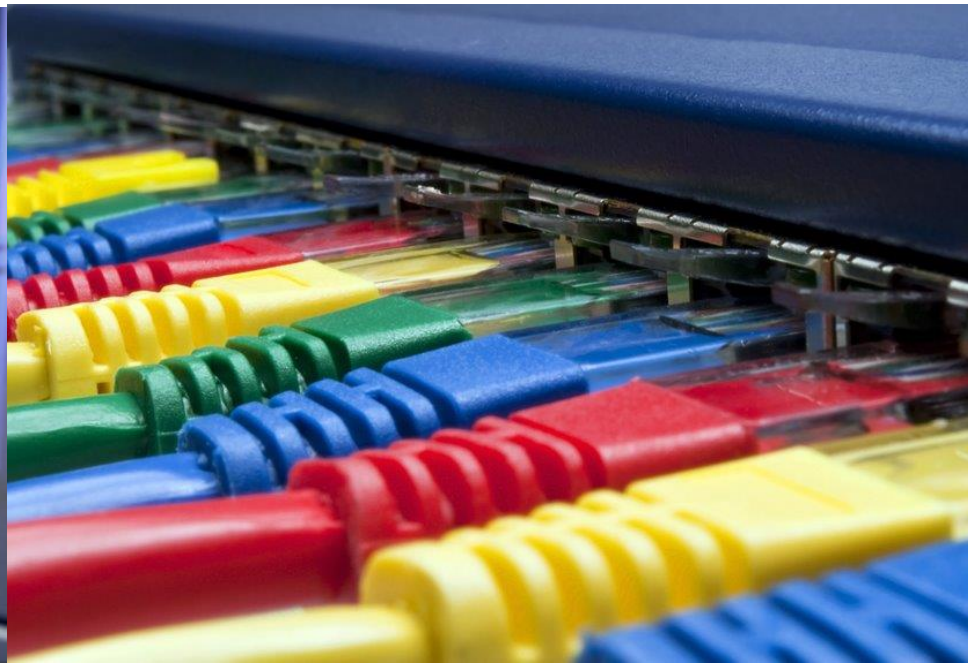
Aristotle Cloud Federation

- NSF CC*DNI DIBBs project (2015-2020)
  - Cornell (PI); University at Buffalo, UC Santa Barbara (co-PIs)
- Federated cloud model goals
  - Optimize time to science
  - Share resources “fairly” among institutions
  - Cross-institution allocations
  - Burst to remote federated cloud sites or public cloud during peak usage
  - Open XDMoD cloud monitoring and metrics

Layered Security

Cloud perimeter, stack & instances





Cloud perimeter security

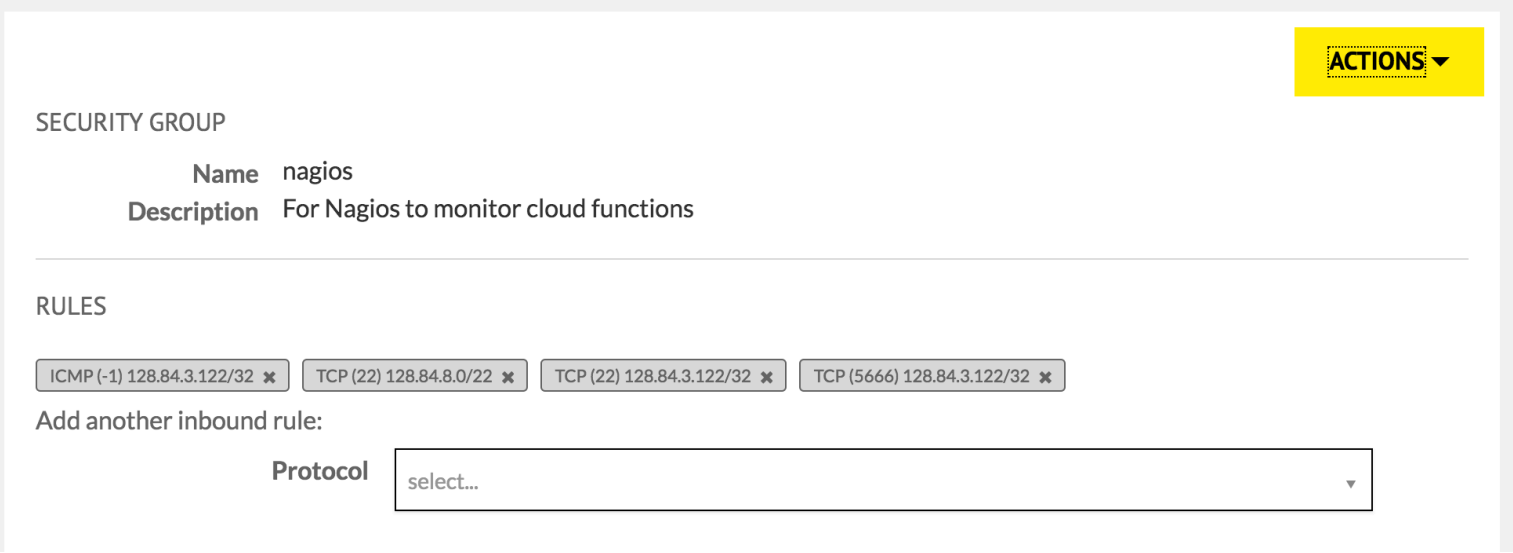
- Red Cloud installations are located in central data centers in Ithaca and NYC on their own subnets
- Leverage central IT security for
  - Network access control by campus firewall
    - Restricts network access to Red Cloud infrastructure
      - Cloud controllers, storage, nodes running cloud instances
    - Allows unrestricted network access to cloud instances
      - Cloud instances are protected by user-defined policies for its security group per AWS architecture
  - Monitoring
    - Red Cloud subnet is monitored like a network in the data center
    - Security incident reporting and handling
      - CAC systems staff serves as liaisons between IT security and users

Cloud stack security features

- Red Cloud accounts are integrated with CAC's Active Directory and fully automated account management system
  - PIs and their proxies can add and remove users from their projects
- Eucalyptus Web Console supports InCommon via Globus Auth
  - Enable SSO by all Aristotle Cloud Federation users
- Access to cloud resources and quotas can be defined on per-user basis by PIs via AWS-styled IAM policies

Cloud stack security features (cont.)

- Users can define network access policies for their instances
  - Each instance is placed in a security group during startup
  - Users defines network access policies for the security group
- Default policy denies all inbound access
  - Users must explicitly grant access by protocol, IP address and range
  - User education and easy-to-use management GUI are critical
    - "Why can't I ssh into my new instance?"



Securing cloud instances

- Base Linux and Windows images are maintained by CAC staff
- Linux
  - Initial root access granted by user-specified ssh keypairs
  - Password logins are not allowed in base images
- Windows
  - Can configure Windows images to auto-join domains at startup
- Users are encourage to patch their running instances periodically

Lessons learned

User education and communications are critical

- Capacity planning
  - Forgot to shut down instances? Need new cloud capacity? Time to burst to public cloud?
- Liaison between central IT security and user
  - Who's generating this traffic and why?
- Advocating to enable research
  - Analyzing Twitter data during Super Bowl overwhelms Internet link